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(54) **A transmitter and/or receiver.**

(57) The present invention relates to a method and a radio frequency system for generating the frequencies for a receiver and a transmitter in a radio communication system operating on two different frequency ranges, and to a receiver and a transmitter operating on two different frequency ranges, whereby a first frequency synthesizer generates a first mixer frequency and a second frequency synthesizer generates a second mixer frequency, the reception frequency is first mixed in the first mixer to a first intermediate frequency by the first mixer frequency, and the first intermediate frequency is further mixed to a second intermediate frequency in a second mixer by the second mixer frequency, and whereby the transmission frequency of the transmitter is generated by mixing the transmitted signal in a third mixer up to the transmission frequency by the first and second mixer frequencies. The invention is characterized in that the first mixer frequency (LO1) in the receiver of the radio communication system operating on the first reception frequency range is made different from that in the receiver of the radio communication system operating on the second reception frequency range, and that both the first intermediate frequency (IF1) and the second intermediate frequency (IF2) in a receiver of the radio communication system operating on the first reception frequency range are made equal to those in a receiver of the radio communication system operating on the second reception frequency range. The invention also relates to the use of the methods and the radio frequency systems in a mobile phone.

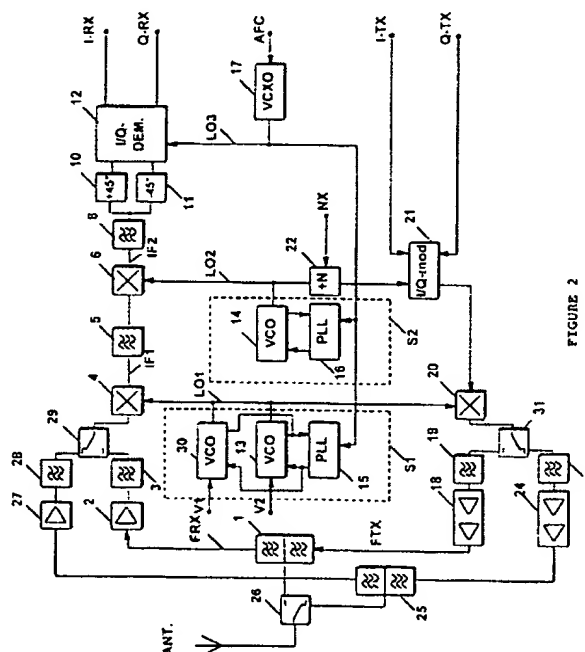


FIGURE 2

The present invention relates to a method and a radio frequency system for generating the frequencies for a receiver and a transmitter in a radio communication system operating on two different frequency ranges, and to a receiver and a transmitter operating on two different frequency ranges, whereby a first frequency synthesizer generates a first mixer frequency and a second frequency synthesizer generates a second mixer frequency, the reception frequency is first mixed in the first mixer to a first intermediate frequency by the first mixer frequency, and the first intermediate frequency is further mixed to a second intermediate frequency in a second mixer by the second mixer frequency, and whereby the transmission frequency of the transmitter is generated by mixing the transmitted signal in a third mixer up to the transmission frequency by the first and second mixer frequencies. The invention also relates to the use of the methods and the radio frequency systems in a mobile phone.

It is well known to use a basic oscillator and one or more frequency synthesizers to generate stable local oscillator frequencies for the modulator of a transmitter and for the demodulator of a receiver. For receiving purposes a mixer frequency is generated, with the aid of which the transmitter's intermediate frequency signal is raised to the transmission frequency. In systems where the difference between the intermediate frequencies used in receiving and transmitting equals the duplex interval it is possible to use the same mixer frequency in the receiver and in the transmitter, and thus in these systems only one synthesizer is required to generate the mixer frequencies. Here the mixer frequency generally means the signal supplied to the local oscillator port of a mixer, modulator or demodulator. In systems where the difference between the intermediate frequencies used in receiving and transmitting differs from the duplex interval it is necessary to use at least two synthesizers in order to generate the mixer frequencies for the receiver and the transmitter.

Different systems use different frequency ranges and thus there must be separate synthesizers supplying different frequencies for systems operating at these different frequencies. Thus it is necessary to design and manufacture different circuits in order to generate the required frequencies in mobile phones of different systems. For instance manufacturers of GSM (Groupe Special Mobile) mobile phone systems and PCN mobile phone systems have to manufacture different RF parts for the GSM and the PCN telephones, even when the systems are generally similar digital cellular radio systems, except that the GSM operates on the 900 Mhz frequency range and the PCN on the 1800 Mhz frequency range.

The patent application FI-915220 (the corresponding European application was published as no. 541 305) presents an RF system solution which is easily changed to either of two different frequency ranges, whereby in a radiotelephone of a first radiotelephone system the mixer frequencies are generated so that they are equal to those of a radiotelephone of a second radiotelephone system operating on different transmit and reception frequency ranges, whereby a radiotelephone of the first radiotelephone system takes from the mixing results of the mixers a result which is different from that in a radiotelephone of a second radiotelephone system operating on different transmit and reception frequency ranges. Then the same frequency synthesizers can be used in radiotelephones operating on two different frequency ranges.

However, the selection of mixing frequencies so that the same mixing frequencies can be used in a system operating at two different frequencies has in practice resulted in a situation where the synthesizer solution presented in the above mentioned patent application had to be made very complicated, whereby e.g. in the control loop of the synthesizer with the higher frequency it was necessary to use a mixer in order to avoid problems when generating the mixing frequencies. Even if it presents a method which with partly common RF parts can generate the frequencies for two radiotelephones operating on different frequency ranges, with this solution it is, however, very inconvenient to realize a combined telephone operating on two different frequency ranges, because it would require e.g. the use of different intermediate frequency filters on different frequency ranges.

The present invention provides a method and a radio frequency system, with which the frequencies required to transmit and receive in a radio communication system operating on two different frequency ranges can be generated with substantially common RF parts, whereby it is simple to realize a receiver, a transmitter and a transceiver and thus a mobile phone operating on two different frequency ranges. The invention can well be used in mobile phones of a mobile phone system utilizing two different frequency ranges, such as in the GSM and the PCN mobile phone systems, as well as in a mobile phone operating on two different frequency ranges. This is realized by using the same intermediate frequencies on both frequency ranges, but a different frequency as the first mixing frequency on each frequency range, in that the frequency is suitably selected for each frequency range so that the received frequency of both different frequency ranges can be mixed down to the same first intermediate frequency.

A method according to the invention for generating the frequencies required in the receiver of a radio communication system operating on two different frequency ranges is characterized in that the first mixer frequency in the receiver of the radio communication system operating on the first reception frequency range is made different from that in the receiver of the radio communication system operating on the second reception frequency range.

quency range, and that said first intermediate frequency (IF1) in the receiver of the radio communication system operating on the first reception frequency range is made equal to that in the receiver of the radio communication system operating on the second reception frequency range.

An RF system of the receiver in a radio communication system according to the invention operating on two different frequency ranges is characterized in that - for the receiver of the radio communication system operating on the first reception frequency range it comprises a first frequency synthesizer generating a first output frequency and for the receiver of the radio communication system operating on the second reception frequency range it comprises a first frequency synthesizer generating a second output frequency, and - for the receiver of the radio communication system operating on the first reception frequency range it comprises first filter means arranged after the first mixer and passing the first intermediate frequency, and for the receiver of the radio communication system operating on the second reception frequency range it comprises second filter means arranged after the first mixer and passing a frequency of the same magnitude as the first filter means of the radio communication system operating on the first reception frequency.

A method according to the invention for generating the frequencies required in a receiver operating on two different frequency ranges is characterized in that when the receiver operates on the first reception frequency range the first mixer frequency is made different from that first mixer frequency when the receiver operates on the second reception frequency range, and that when the receiver operates on the first reception frequency range said first intermediate frequency is made equal to that first intermediate frequency when the receiver operates on the second reception frequency range.

An RF system of the receiver according to the invention operating on two different frequency ranges is characterized in that a first frequency synthesizer generating two different output frequencies, whereby the output of the first frequency synthesizer is a first frequency when the receiver operates on the first reception frequency range, and whereby the output of the first frequency synthesizer is a second frequency when the receiver operates on the second reception frequency range, and- first filter means arranged after the first mixer and passing the same first intermediate frequency when the receiver operates on the first reception frequency range as when it operates on the second reception frequency range.

A method according to the invention to generate the frequencies required in a transmitter in a radio communication system operating on two different frequency ranges is characterized in that the first mixer frequency in a transmitter of a radio communication system operating on the first transmit frequency range is made different from that first mixer frequency in a transmitter of a radio communication system operating on the second transmit frequency range, and the second mixer frequency in a transmitter of a radio communication system operating on the first transmit frequency range is made equal to the first mixer frequency in a transmitter of a radio communication system operating on the second transmit frequency range.

An RF system of the transmitter in a radio communication system according to the invention operating on two different frequency ranges is characterized in that a transmitter of a radio communication system operating on the first transmit frequency range it comprises a first frequency synthesizer providing a first output frequency, and in a transmitter of a radio communication system operating on the second transmit frequency range it comprises a first frequency synthesizer providing a second output frequency, and that in a transmitter of a radio communication system operating on the first transmit frequency range it comprises a second frequency synthesizer providing a second mixer frequency, and in a transmitter of a radio communication system operating on the second transmit frequency range it comprises a second frequency synthesizer providing a second mixer frequency, which is of the same magnitude as that of the frequency synthesizer of the radio communication system operating on the first transmit frequency range.

A method according to the invention to generate the frequencies required in a transmitter operating on two different frequency ranges is characterized in that when the transmitter is operating on the first transmit frequency range the first mixer frequency is generated to be different from that mixer frequency when the transmitter is operating on the second transmit frequency range, and that when the receiver operates on the first reception frequency range the second mixer frequency is made equal to the first mixer frequency when the receiver operates on the second reception frequency range.

An RF system of the transmitter according to the invention operating on two different frequency ranges is characterized in that a first frequency synthesizer generating two different first output frequencies, whereby the output of the first frequency synthesizer is a first frequency when the receiver operates on the first reception frequency range, and whereby the output of the first frequency synthesizer is a second frequency when the receiver operates on the second reception frequency range, and a second frequency synthesizer generating on the first transmit frequency range a second mixer frequency, which is equal to that on the second transmit frequency range.

The methods and RF systems according to the invention can be used in a mobile phone of a mobile phone system operating on two different frequency ranges, and in a mobile phone operating on two different fre-

quency ranges. The methods and the RF systems according to the invention required to generate the frequencies can as well be used in a paging device of a paging system operating on two frequency ranges, and thus the invention is not restricted only to radiotelephones.

The methods and the RF system for a transmitter and a receiver will be described in more detail below by describing a mobile phone according to the invention utilizing methods according to the invention to generate the frequencies of the transmitter and the receiver and an RF system according to the invention in the transmitter and the receiver. The invention is described with reference to the enclosed figures, in which:

figure 1 shows a block diagram of mobile phone RF parts according to the invention which can be used in a mobile phone of a mobile phone system operating on two different frequency ranges; and

figure 2 shows a block diagram of the RF parts in a combined telephone according to the invention operating on two different frequency ranges.

In the description we refer to frequency values, which were selected as examples in order to generate frequencies used in the GSM and the PCN systems. The transmit and receive frequencies used in these systems are as follows, and in order to implement the invention we selected the following internal frequencies of the

20	GSM	receive	935.2	...	959.8	Mhz
		transmit	890	...	915	Mhz
		mixer frequency LO1	1215.6	...	1240.2	Mhz (RX)
			1222.6	...	1247.2	Mhz (TX)
		mixer frequency LO2	332.4			Mhz
		frequency LO3	26 Mhz			
30	PCN	receive	1805.2	...	1879.8	Mhz
		transmit	1710.2	...	1784.8	Mhz
		mixer frequency LO1	1524.8	...	1599.4	Mhz (RX)
			1544.0	...	1618.6	Mhz (TX)
		mixer frequency LO2	332.4			Mhz
		demodulator		local		oscillator
35		frequency LO3	26 Mhz			

Here we can see that the systems have different first mixer frequencies.

Figure 1 shows a block diagram of a mobile phone's RF parts in accordance with the invention which can be used in a mobile phone of a mobile phone system operating on two different frequency ranges. The blocks 2...12 represent a transmitter, the blocks 13...16 represent a synthesizer, and the blocks 18...21 represent a transmitter. The figure shows two frequency synthesizers S1 and S2. The area S1 shown by broken lines represents the main synthesizer which is suitably selected to operate in the GSM system on the 1200 Mhz range and in the PCN system on the 1500 Mhz range. The synthesizer S2 operates in both systems at a frequency of about 300 Mhz. The first synthesizer S1 comprises a phase locked loop, in which as separate blocks are shown a voltage controlled oscillator 13 and a block 15 containing the phase locked loop filter, amplifier, frequency divider and a phase detector and operating on the variable frequency range LO1 (= first mixer frequency). The second synthesizer S2 comprises a phase locked loop, in which as separate blocks are shown a voltage controlled oscillator 14 and a block 16 containing the phase locked loop filter, amplifier, frequency divider and a phase detector and operating at a fixed frequency LO2 (= second mixer frequency). The design and realization of the phase locked loop is known per se by a person skilled in the art, and therefore it will not be described in further detail here. The reference frequency LO3 of the synthesizers S1 and S2 is generated by the 26 Mhz crystal oscillator 17, whose frequency is also supplied to the demodulator 12 as the third local oscillator signal of the receiver.

The received signal is supplied from the antenna ANT through the duplex filter 1 as the received frequency FRX to the preamplifier 2 and through the RF filter 3 to the mixer 3, where it is mixed with the first mixer fre-

quency LO1 generated by the synthesizer S1 in order to provide the first intermediate frequency IF1. Both in the GSM and the PCN systems we use as the first intermediate frequency IF1 a comparatively high frequency in order to avoid spurious response frequencies, which are due to the comparatively broad transmit and reception frequency range. The high first intermediate frequency is also advantageous in GSM, because then the required RF filters, such as ceramic filters, will be smaller and cheaper. From the mixer 4 the signal passes through the first intermediate frequency filter 5 to the second mixer 6, in which it is mixed with the mixer frequency LO2 supplied by the synthesizer S2 in order to provide the second intermediate frequency IF2. From the second mixer 6 the signal passes through the second intermediate frequency filter 8 and through the +45° and -45° phase shift blocks 10 and 11 to the demodulator 12, preferably an I/Q-demodulator, which also receives the local oscillator frequency LO3.

In this embodiment in accordance with the invention the receiver I/Q-demodulator 12 operates in a slightly different way compared to a traditional I/Q-demodulator. Generally the intermediate frequency signal supplied to a demodulator is at the same frequency as the local oscillator signal. In the embodiment presented here for the GSM and PCN systems the local oscillator frequency LO3 is half of the intermediate frequency IF2. These frequencies can be processed with demodulators of a certain type, for instance with a demodulator of the type presented in patent application FI-915892.

Instead of the I/Q-demodulator 12 it is also possible to use an A/D-converter operating with a sub-sampling principle, and then the converter clock frequency is generated from the frequency LO3.

Correspondingly, in the transmitter the transmit signal I-TX, Q-TX supplied to the modulator is further supplied from the modulator 21, preferably an I/Q-modulator which in addition to the transmitted signal receives a frequency provided by the second mixer frequency LO2 divided by the divider 22, to the mixer 20, in which the signal is mixed up to the transmit frequency FTX by the first mixer frequency LO1. From the mixer 20 the signal is supplied through a transmit frequency RF filter 19 to the power amplifier 18, and from there the amplified signal is supplied through the duplex filter 1 to the antenna ANT.

In accordance with the invention the first and the second intermediate frequencies, respectively, are arranged to be equal in telephones using different transmit and reception frequency ranges, such as in telephones of the GSM and the PCN systems. Regarding the invention it does not make any difference whether the intermediate frequencies are generated from different mixing results in systems operating on different frequency ranges, if only the intermediate frequencies are of the same magnitude. The frequencies for each system may be selected. In an example in which for GSM LO1 is chosen to be larger than FRX and FTX and for PCN LO1 is smaller than FRX and FTX, the frequencies may be selected as follows:

GSM:	1st intermediate frequency	$IF1 = LO1 - FRX = 280.4 \text{ Mhz}$
	2nd intermediate frequency	$IF2 = LO2 - IF1 = 52 \text{ Mhz}$
	transmit frequency	$FTX = LO1 - LO2$
PCN:	1st intermediate frequency	$IF1 = FRX - LO1 = 280.4 \text{ Mhz}$
	2nd intermediate frequency	$IF2 = LO2 - IF1 = 52 \text{ Mhz}$
	transmit frequency	$FTX = LO1 + (LO2)/2$

The third local oscillator frequency LO3 is the same as the frequency generated by the crystal oscillator 17. A suitable crystal oscillator frequency for the GSM and the PCN systems is 26 Mhz, from which it is possible to form all clock frequencies required in the telephone. In order to minimize problems with spurious response and spurious radiation our calculations show that it is most preferable to use 280.4 Mhz as the first intermediate frequency. The intermediate frequency could be some other frequency, and besides the spurious problems it will not have any substantial effect on other factors than the frequency of the main synthesizer S1.

The signal supplied by the second synthesizer S2 as a carrier signal to the transmitter modulator 21 is divided by the divider 22 to form a suitable frequency. Here we use number 2 as divisor for the PCN system, and number 1 in the GSM system (i.e. no divisor is required in GSM). With the aid of the divisor the frequency range required from the main synthesizer S1 to provide the appropriate frequency LO1 for both GSM and PCN in each of transmit and receive modes and in particular to keep the variation in frequency of the LO1 between transmit and receive for the same system can be narrowed if necessary by changing the value of N. In the PCN system of this example, the frequency jump of the first synthesizer S1 between receive and transmit phases can be made shorter, as is shown below.

The difference between the transmit and receive ranges in the PCN system is 95 Mhz. Without the divider 22 the synthesizer's frequency change dLO1 between transmitting and receiving is:

$$\begin{aligned}
 \text{dLO1} &= \text{IF1} - \text{LO2} - 95 \text{ Mhz} \\
 &= 280.4 \text{ Mhz} - 332.4 \text{ Mhz} - 95 \text{ Mhz} \\
 &= -147 \text{ Mhz}
 \end{aligned}$$

If the frequency LO2 supplied to the modulator is divided by two, then the synthesizer's frequency change is:

$$\begin{aligned}
 \text{dLO1} &= \text{IF1} - (\text{LO2})/2 - 95 \text{ Mhz} \\
 &= 280.4 \text{ Mhz} - 166.2 \text{ Mhz} - 95 \text{ Mhz} \\
 &= 19.2 \text{ Mhz}
 \end{aligned}$$

In the GSM system the corresponding frequency change is:

$$\text{dLO1} = \text{IF2} - 45 \text{ Mhz} = 7 \text{ Mhz}$$

Figure 2 shows a block diagram of the RF parts in a combined telephone operating on two frequency ranges according to the invention.

In the receiver and transmitter there is for each frequency range a separate receiver front-end comprising a pre-amplifier 2, 27 and an RF filter 3, 28; and on the transmit side there are filters 19, 23 and a power amplifier 1, 25 for each frequency range.

In order to use the different parts when operating on different frequency ranges, change-over switches 26, 29, 31 are arranged in the antenna connection and in the transmitter mixer ports on the antenna side. When operating with two different frequency ranges the signal receiving side contains two duplex filters 1, 25; two preamplifiers 2, 27; and two receiver RF filters 3, 28. In a corresponding way the transmission side uses two transmitter RF filters 19, 23; two power amplifiers 18, 24; and two duplex filters 1, 25. The switches 26, 29, 31 select the respective one of the two similar blocks to be used. In order to generate the two different first mixer frequencies LO1 in accordance with the invention, two voltage controlled oscillators 13, 30 are arranged in the synthesizer S1, one of which is activated with the controls V1 and V2, depending on the frequency range with which the device operates, e.g. on the frequency range of the GSM or the PCN. The oscillator supply voltages can be used as controls V1 and V2 (i.e., the supply voltage is connected to only one of them). Each oscillator 13, 30 provides as output a different frequency. Instead of separate oscillators it would be possible to use two different frequency synthesizers S1 to generate the different mixing frequencies LO1, of which one is selected depending on the operating frequency range. Another alternative is to use one synthesizer S1 having two different frequency dividers in the phase locked loop 15, so that one of them is selected to be used. The divisor of the divider 22 is selected with the control NX. The divisor is 2 for the PCN system and 1 for the GSM system. At the frequencies shown here the antenna is a combination antenna for several frequency ranges. In other respects the RF parts are identical for both transmit and reception frequency ranges.

The RF change over switches 26, 29, 31 may be realized e.g. with PIN diodes or with GaAs FET transistors. Instead of switches 26, 29, 31 it is also possible to apply any known method to change the path of the RF signal.

With embodiments of the invention it is possible to realize a combined telephone for two different transmit and reception frequency ranges by using the same RF part for both frequency ranges, except for the parts in the transmitter output and in the receiver input and the synthesizer S1.

In order to generate the mixer frequencies LO1, LO2 according to the invention we can use synthesizer circuits S1 and S2 with such a low noise level that no mixing is required in the synthesizer. In a combined telephone operating on two different frequency ranges, e.g. in a combined telephone operating in the PCN and GSM systems, the intermediate frequency filters can be realized with SAW technology, so that a good short distance selectivity is obtained even at high frequencies with these filters.

Embodiments of the invention may be used in GSM and PCN mobile phones, but the invention is not restricted to the frequency ranges of these systems, but it may be applied e.g. in the DECT system and in paging systems. Methods and systems in accordance with the invention reduce the development costs and times for the RF parts, because the same RF parts can be used in two different systems. It will be more profitable to realize the RF parts as integrated circuits, because the same circuits can be used in several systems, and

thus the manufacturing batch size will be larger and the unit price of the circuit will be lower, because the costs for development and manufacture of the integrated circuits will be lower. Moreover, the investment costs in the production will decrease as the same production line can be used for the manufacture of telephones of both systems (GSM, PCN), whereby only slight changes have to be made in the component insertion and testing programs.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

The scope of the present disclosure includes any novel feature or combination of features disclosed therein either explicitly or implicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed by the present invention.

Claims

1. A transmitter and/or receiver for operating in first and second respective frequency ranges comprising means for providing a first mixer signal (LO1) for use in a transmitting and/or receiving branch such that the first mixer signal is mixed with an incoming signal to provide a first intermediate frequency signal and the first intermediate frequency signal is further mixed to provide a second intermediate frequency signal, and/or a signal of the first intermediate frequency is mixed with the first mixer signal to provide an outgoing signal characterised in that the first intermediate frequency is substantially the same for each of the first and second respective frequency ranges.
2. A transmitter and/or receiver according to claim 1 wherein the means for providing the first mixer signal comprises a frequency synthesizer.
3. A transmitter and/or receiver according to claim 2 wherein the frequency synthesizer comprises first and second frequency oscillators (13, 30) for providing the first mixer signal in the first and second frequency ranges respectively.
4. A transmitter and/or receiver according to any preceding claim comprising a second frequency synthesizer for providing a second mixer signal.
5. A transmitter and/or receiver according to claim 4 wherein the second mixer signal is substantially the same for each of the first and second respective frequency ranges.
6. A transmitter and/or receiver according to claim 4 or claim 5 wherein in the receiving branch the second frequency synthesizer is coupled to a first mixer providing the second intermediate frequency signal.
7. A transmitter and/or receiver according to claim 7 wherein the second mixer signal is divided to provide a signal of suitable frequency to the first mixer.
8. A transmitter and/or receiver according to any one of claims 4 to 7 wherein in the transmission branch the second frequency synthesizer is coupled to a second mixer for providing the first intermediate frequency signal.
9. A transmitter and/or receiver according to claim 8 wherein the second mixer signal is divided to provide a signal of suitable frequency to the second mixer.
10. A transmitter and/or receiver according to any preceding claim comprising a filter in the receiving branch for passing the first intermediate frequency signal.
11. A transmitter and/or receiver according to any preceding claim comprising a filter in the receiving branch for passing the second intermediate frequency signal.
12. A transmitter and/or receiver according to any preceding claim for use in a mobile phone operable for use in respective mobile phone systems transmitting and receiving in respective first and second frequency ranges.

13. A transmitter and/or receiver according to claim 12 wherein the mobile phone systems are the Groupe Special Mobile (GSM) and Personal Communications Network (PCN).

5 14. A method for providing signals for a transmitter and/or receiver operable in first and second respective frequency ranges comprising providing a first mixer signal (LO1) for use in a transmitting and/or receiving such that an incoming signal is mixed with the first mixer signal to provide a first intermediate frequency signal and the first intermediate frequency signal is further mixed to provide a second intermediate frequency signal, and/or a signal of the first intermediate frequency is mixed with the first mixer signal to provide an outgoing signal, characterised in that the first intermediate frequency is substantially the same for each of the first and second respective frequency ranges.
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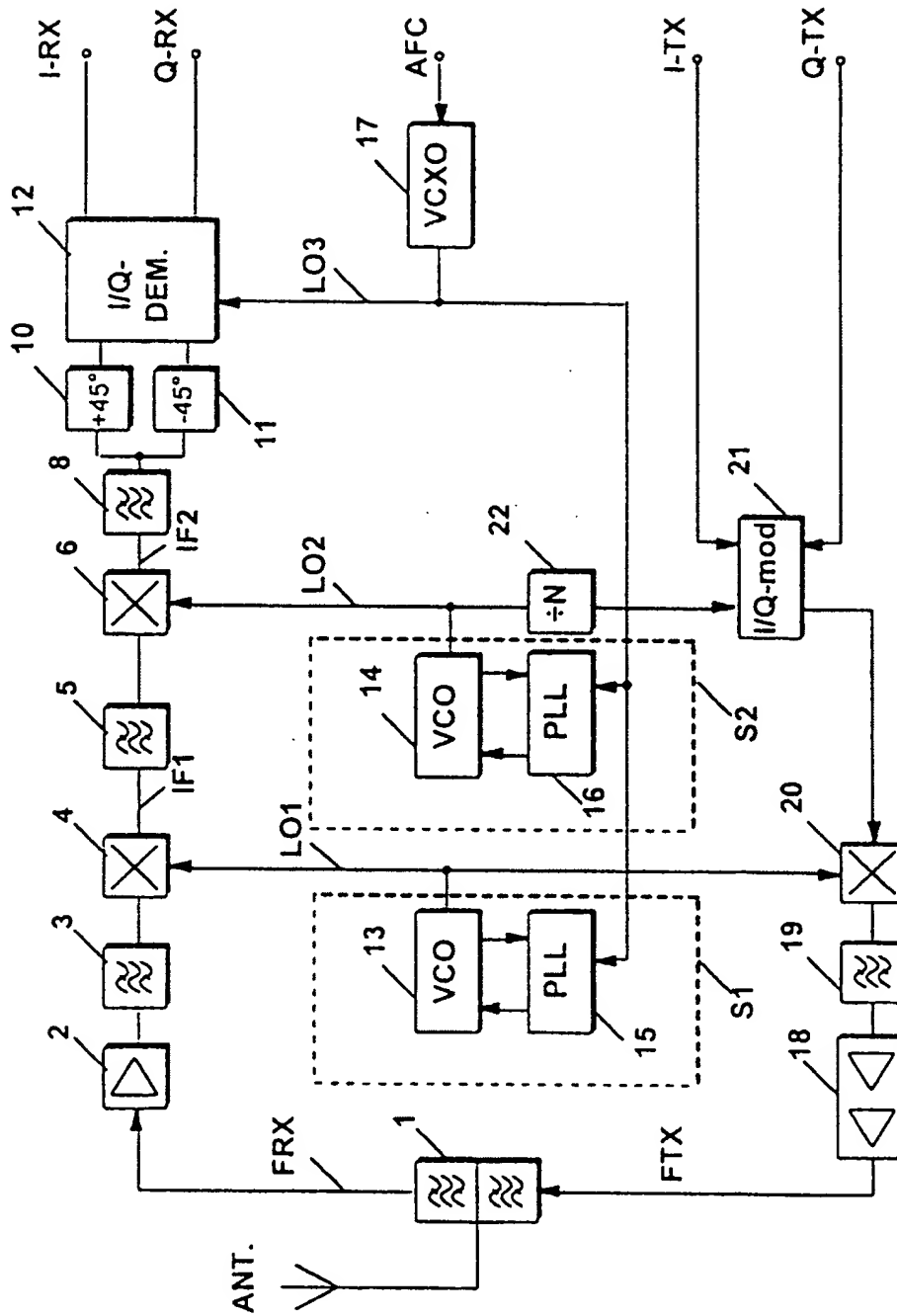


FIGURE 1

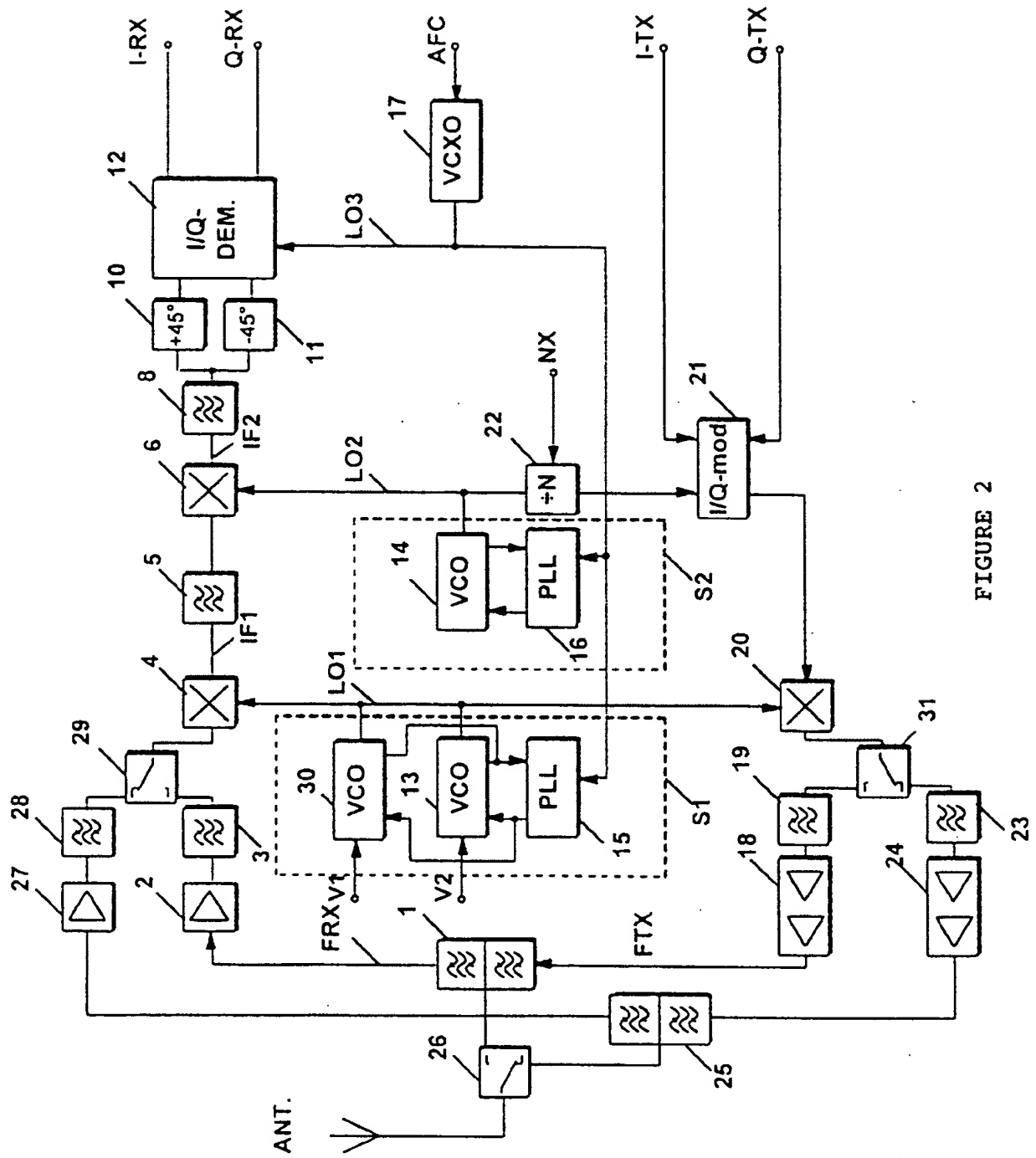


FIGURE 2